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Sampling and Management of Corn Rootworm in New York Field Corn

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Northern corn rootworm, *Diabrotica longicornis,* and western corn rootworm, *Diabrotica virgifera virgifera,* are of increasing economic concern in New York. Northern corn rootworm has been in New York for many years, causing damage to field corn in isolated locations. Western corn rootworm was first collected in western New York during 1979 and since then has spread across the state, increasing in population. The potential for economic losses in field corn from rootworms has increased significantly since the introduction of western corn rootworm into New York.

Description and Life Cycle

Identification of the two different species of corn rootworms is fairly easy. Western corn rootworm adults are yellow and brown with yellow stripes on their wings. In contrast, northern corn rootworm adults are bright yellow green (fig. 1).

Both species have similar life cycles (fig. 2). Adults emerge from the soil in midsummer and migrate to pollinating corn fields where they feed on corn pollen and silks. If adult emergence occurs prior to corn pollination, adult beetles also feed on the leaves and the developing tassel. After approximately three weeks of feeding, the female beetles begin laying eggs around the base of existing corn plants and in soil cracks. Egg laying continues until several killing frosts have killed the adult beetles. Eggs remain dormant in the soil throughout the winter and hatch the following year during mid- to late May. After hatching, larvae migrate through the soil, locate growing corn roots, and feed until mid-July when they enter the pupal stage. Adult beetles emerge in late July to begin laying eggs three weeks later.

Damage and Economic Losses

Economic losses from corn rootworm are caused by extensive larval root feeding during late spring and early summer. Larval root feeding interferes with water and nutrient uptake and reduces the yield potential of the crop during periods of water stress. In addition, feeding on the brace roots weakens the corn stalk's standability, resulting in lodging of the corn stalks. Because severely lodged fields are difficult to harvest, harvest losses and yield reductions occur.

Preventing Losses from Rootworms

Losses from corn rootworms can be easily prevented by monitoring the population of corn rootworm adults during the four-week period beginning after pollen shed. By counting the number of corn rootworm adults on 55 plants in the corn field each week, a decision can be made whether the field has potential for economic damage from corn rootworm the next year. If the field does not have potential for damage, then corn can be planted safely the next growing season without the use of a soil insecticide during planting. If the field does have potential for damage, then it should be rotated to another crop or treated with a soil insecticide during planting the following year.

Fig.1. Corn rootworm adults

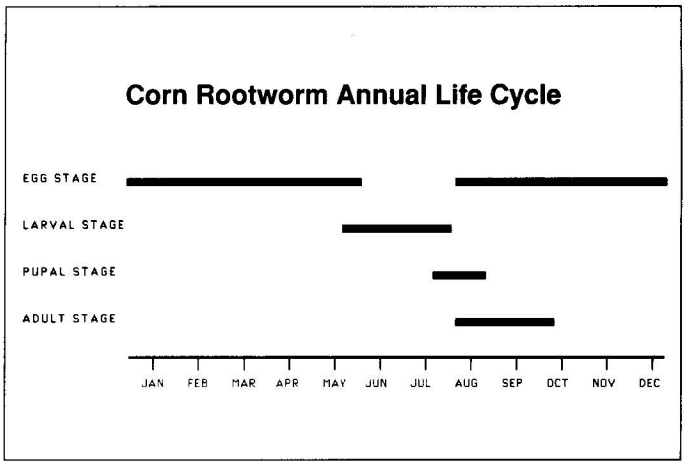

Fig. 2. Annual life cycle of both the western and the northern corn rootworm

Selecting an Action Level

Throughout the corn belt, 0.75 to 1 beetle per plant is used as an action level for grain corn. In these areas, western corn rootworm dominates the corn rootworm population, and damage is evident some years at these action levels. Similar action levels are used throughout the corn belt on silage corn. Under New York conditions, action levels for silage corn are currently unknown. Field trials conducted during 1989 and 1990 on a silt-loam soil, however, indicate measurable silage loss occurs with 3 to 5 beetles per plant. In general, silage corn can tolerate more larval feeding than grain corn, but the exact action level is unknown. In addition, fields with sandy soils can tolerate higher beetle counts because the abrasive action of the sand kills a significant number of newly hatched larvae before larval root feeding can occur.

Sampling Window

Adult rootworm sampling in continuous corn fields should be initiated after mature females ready to lay eggs have been detected in the field. Start checking females for the presence of eggs one week after pollination in the earliest flowering fields. Females are the larger-sized beetles with expanded abdomens and can be checked for eggs in the following way. Capture the beetle between your thumb and forefinger and squeeze the contents of the beetle out the abdomen. Mature eggs are white, about the size of a pin head, and shaped like footballs. Check at least a dozen beetles for the presence of eggs. Once mature females have been detected in a field, sample the field at seven-day intervals until either an economic population has been recorded in a single sampling or a subeconomic population has been recorded for three consecutive weeks.

Different courses of action, however, are required in the four sampling situations described below.

1. If an economic population is detected resulting in a rotate/treat decision after a single sampling, sampling a second week is unnecessary. This field is considered at risk for corn rootworm damage and should be rotated out of corn, or a soil insecticide for corn rootworm control should be used the next year at planting.
2. If an economic population is detected resulting in a rotate/treat decision in the **second sampling week** but not the first week, sampling the third week is unnecessary. This field is considered at risk for corn rootworm damage and should be rotated out of corn, or a soil insecticide for corn rootworm control should be used the next year at planting.
3. If an economic population is detected resulting in a rotate/treat decision in the **third or subsequent sampling weeks** but not the first two weeks, this field is considered at risk for corn rootworm damage. It should be rotated out of corn, or a soil insecticide for corn rootworm control should be used the next year at planting.
4. If an economic population is not detected during the three sequential sampling periods, the field is considered not at risk for corn rootworm damage. A soil insecticide for rootworm control is not needed at planting. An insecticide seed treatment is still necessary, however, for control of seed corn maggot.

Sampling of first-year corn fields should be initiated **two weeks after pollination** and should continue at seven-day intervals until the population of corn rootworm adults peaks then declines for two weeks, **or** until an economic population is detected resulting in a rotate/treat decision.

Sampling Technique

Corn rootworm adults are easily startled and drop off the plant when disturbed. Plants must be searched quietly and carefully to locate and count the beetles present on the plant. As you approach the plant, grasp the ear silks in one hand to confine any beetles in the silks. Search the remainder of the plant quickly, starting with the tassel and working down the plant. Look on both sides of the leaves and in the leaf axials. After searching the entire plant, search the ear silks for any remaining beetles. Record the number of beetles found on the plant by species—that is, the number of western corn rootworm beetles and the number of northern corn rootworm beetles. Both numbers are needed to make a treatment decision. Repeat this procedure, searching and recording the number of each species found, until 55 plants have been examined.

To calculate the average number of beetles per plant, first total the numbers recorded for each species. In New York State, the presence of 1 western corn rootworm beetle is equal to the presence of 2 northern corn rootworm beetles. Therefore, divide the total number of northern corn rootworm adults found in the field by 2. This converts the number of northern corn rootworm beetles found to western corn rootworm equivalents. Then add the total number of western corn rootworm beetles counted in the field to the number of western corn rootworm equivalents. To calculate the average number of beetles per plant for the field, divide this total by 55, the number of plants sampled.

For example:

55 plants searched
100 = total northern corn rootworm beetles found in the field
60 = total western corn rootworm beetles found in the field
100 northern corn rootworm beetles/2 = 50 western corn rootworm equivalents
50 + 60 = 110 corn rootworm beetles
110 beetles/55 plants = 2 beetles/plant, the field average

Fields need to be sampled for a minimum of three consecutive weeks during the optimum sampling window before a management decision can be made. If the average number of beetles per plant exceeds the selected action level (usually 1 beetle per plant), the field needs to be rotated out of corn or treated with a soil insecticide at planting the next year if corn is grown in the field.

Sequential Sampling Procedure

Sequential sampling methods combine sampling procedures with treatment thresholds to maximize sampling accuracy and minimize sampling efforts. In many situations, accurate rootworm no treat or rotate/treat decisions can be made more rapidly using the sequential sampling procedure illustrated below than using the sampling methods described previously. Sequential sampling, however, depends on an even distribution of corn rootworm beetles across the field. The procedure should be used only when the corn in the field is uniform in physiological development. In fields with uneven development either from uneven germination or water stress, the beetles will be clumped on pollinating plants and sequential sampling should not be used.

An Example of the Sequential Sampling Procedure

1. Inspect 3 plants randomly selected from three different sites in the field for the presence of corn rootworm adults. Count the adults observed on the 3 plants by species. Divide the total number of northern corn rootworm beetles by 2 to convert to western corn rootworm equivalents. Then calculate the total number of adults observed on the 3 plants (western corn rootworm adults plus western corn rootworm equivalents). Refer to the sequential sampling table for the action level you selected (tables 1 to 7).
2. Locate the row in the table corresponding to 3 plants sampled. Compare the number of corn rootworm adults counted on the 3 plants with the numbers listed under each of the three columns. If the number of observed corn rootworm adults falls within the range of numbers listed in a specific column, follow the instruction at the head of the column.

For example, for an action level of 1.0 corn rootworm beetle per plant (table 1), if the total number of corn rootworm adults (western corn rootworm adults plus western corn rootworm equivalents) on 3 plants is 11 or more, the field has exceeded the action level and no further sampling is necessary for the remainder of the season. If the field is planted to corn the following growing season, a soil insecticide for corn rootworm control is recommended to prevent economic losses.

If the total number of corn rootworm adults (western corn rootworm adults plus western corn rootworm equivalents) on 3 plants falls between 0 and 10, another plant needs to be sampled. If no more than 1 corn rootworm adult is detected after 9 plants have been sampled, the field should be resampled in seven days. If no decision is reached after 55 plants have been sampled (the number of beetles counted falls under the continue sampling column), divide the total number of corn rootworm adults (western corn rootworm adults plus western corn rootworm equivalents) by 55, the total number of plants sampled. If this number is greater than or equal to the selected action level (usually, and in this example, 1 beetle per plant), the field needs to be treated with a soil insecticide the next year if the field is planted to corn.

Example 1. After carefully searching 3 plants for beetles, you find a total of 7 beetles (western corn rootworm adults plus western corn rootworm equivalents). You look at the row for 3 plants sampled in table 1 (action level = 1 beetle per plant) and find that a total of 7 beetles falls under the continue sampling column. After you sample a fourth plant, the total beetle count rises to 12 beetles (western corn rootworm adults plus western corn rootworm equivalents). This number falls under the last column of table 1 (in the row for 4 plants sampled), indicating an economic infestation is present in the field. No further sampling for rootworm beetles is necessary and a soil insecticide for corn rootworm control should be used at planting the next year.

Example 2. After carefully searching 3 plants for beetles, you do not find any beetles. You look at the row for 3 plants sampled in table 1 (action level = 1 beetle per plant) and find that 0 beetles falls under the continue sampling column. If you continue to find no beetles after sampling 9 plants, you should resample the field in seven days.

Table 1. Action level = 1.0 corn rootworm beetle per plant

No. Plants Sampled	Noneconomic Population–Resample in 7 days	Continue Sampling	Economic Population
3	–	0-10	11
4	–	0-11	12
5	–	0-12	13
6	–	0-13	14
7	–	0-14	15
8	–	0-15	16
9	1	2-16	17
10	2	3-17	18
11	3	4-18	19
12	4	5-19	20
13	5	6-20	21
14	6	7-21	22
15	7	8-22	23
16	8	9-23	24
17	8	9-24	25
18	9	10-25	26
19	10	11-26	27
20	11	12-26	27
21	12	13-27	28
22	13	14-28	29
23	14	15-29	30
24	15	16-30	31
25	16	17-31	32
26	17	18-32	33
27	18	19-33	34
28	19	20-34	35
29	20	21-35	36
30	21	22-36	37
31	22	23-37	38
32	23	24-38	39
33	24	25-39	40
34	25	26-40	41
35	26	27-41	42
36	27	28-42	43
37	28	29-43	44
38	29	30-44	45
39	30	31-45	46
40	31	32-46	47
41	32	33-47	48
42	33	34-48	49
43	34	35-49	50
44	35	36-50	51
45	36	37-51	52
46	37	38-52	53
47	38	39-53	54
48	39	40-54	55
49	40	41-55	56
50	41	42-56	57
51	42	43-57	58
52	42	43-58	59
53	43	44-59	60
54	44	45-60	61
55	45	46-61	62

Table 2. Action level = 1.5 corn rootworm beetles per plant

No. Plants Sampled	Noneconomic Population–Resample in 7 days	Continue Sampling	Economic Population
3	–	0-17	18
4	–	0-19	20
5	–	0-20	21
6	–	0-22	23
7	–	0-23	24
8	–	0-25	26
9	–	0-26	27
10	1	2-28	29
11	2	3-29	30
12	4	5-31	32
13	5	6-32	33
14	7	8-34	35
15	8	9-35	36
16	10	11-37	38
17	11	12-38	39
18	13	14-40	41
19	14	15-41	42
20	16	17-43	44
21	17	18-44	45
22	19	20-46	47
23	20	21-47	48
24	21	22-49	50
25	23	24-50	51
26	24	25-52	53
27	26	27-53	54
28	27	28-54	55
29	29	30-56	57
30	30	31-57	58
31	32	33-59	60
32	33	34-60	61
33	35	36-62	63
34	36	37-63	64
35	38	39-65	66
36	39	40-66	67
37	41	42-68	69
38	42	43-69	70
39	44	45-71	72
40	45	46-72	73
41	47	48-74	75
42	48	49-75	76
43	50	51-77	78
44	51	52-78	79
45	53	54-80	81
46	54	55-81	82
47	56	57-83	84
48	57	58-84	85
49	58	59-86	87
50	60	61-87	88
51	61	62-89	90
52	63	64-90	91
53	64	65-91	92
54	66	67-93	94
55	67	68-94	95

Table 3. Action level = 2.0 corn rootworm beetles per plant

No. Plants Sampled	Noneconomic Population–Resample in 7 days	Continue Sampling	Economic Population
3	–	0-26	27
4	–	0-28	29
5	–	0-30	31
6	–	0-32	33
7	–	0-34	35
8	–	0-36	37
9	–	0-38	39
10	–	0-40	41
11	1	2-42	43
12	3	4-44	45
13	5	6-46	47
14	7	8-48	49
15	9	10-50	51
16	10	11-52	53
17	12	13-54	55
18	14	15-56	57
19	16	17-58	59
20	18	19-60	61
21	20	21-62	63
22	22	23-64	65
23	24	25-66	67
24	26	27-68	69
25	28	29-70	71
26	30	31-72	73
27	32	33-74	75
28	34	35-76	77
29	36	37-78	79
30	38	39-80	81
31	40	41-82	83
32	42	43-84	85
33	44	45-86	87
34	46	47-88	89
35	48	49-90	91
36	50	51-91	92
37	52	53-93	94
38	54	55-95	96
39	56	57-97	98
40	58	59-99	100
41	60	61-101	102
42	62	63-103	104
43	64	65-105	106
44	66	67-107	108
45	68	69-109	110
46	70	71-111	112
47	72	73-113	114
48	74	75-115	116
49	76	77-117	118
50	78	79-119	120
51	80	81-121	122
52	82	83-123	124
53	84	85-125	126
54	86	87-127	128
55	88	89-129	130

Table 4. Action level = 2.5 corn rootworm beetles per plant

No. Plants Sampled	Noneconomic Population–Resample in 7 days	Continue Sampling	Economic Population
3	–	0-36	37
4	–	0-39	40
5	–	0-41	42
6	–	0-44	45
7	–	0-46	47
8	–	0-49	50
9	–	0-51	52
10	–	0-54	55
11	–	0-56	57
12	–	0-58	59
13	3	4-61	62
14	5	6-63	64
15	8	9-66	67
16	10	11-68	69
17	13	14-71	72
18	15	16-73	74
19	18	19-76	77
20	20	21-78	79
21	23	24-81	82
22	25	26-83	84
23	28	29-86	87
24	30	31-88	89
25	33	34-91	92
26	35	36-93	94
27	38	39-96	97
28	40	41-98	99
29	43	44-101	102
30	45	46-103	104
31	48	49-106	107
32	50	51-108	109
33	53	54-111	112
34	55	56-113	114
35	58	59-116	117
36	60	61-118	119
37	63	64-121	122
38	65	66-123	124
39	68	69-126	127
40	70	71-128	129
41	72	73-131	132
42	75	76-133	134
43	77	78-136	137
44	80	81-138	139
45	82	83-141	142
46	85	86-143	144
47	87	88-146	147
48	90	91-148	149
49	92	93-151	152
50	95	96-153	154
51	97	98-156	157
52	100	101-158	159
53	102	103-161	162
54	105	106-163	164
55	107	108-166	167

Table 5. Action level = 3.0 corn rootworm beetles per plant

No. Plants Sampled	Noneconomic Population–Resample in 7 days	Continue Sampling	Economic Population
3	–	0-47	48
4	–	0-50	51
5	–	0-53	54
6	–	0-56	57
7	–	0-59	60
8	–	0-62	63
9	–	0-65	66
10	–	0-68	69
11	–	0-71	72
12	–	0-74	75
13	–	0-77	78
14	3	4-80	81
15	6	7-83	84
16	9	10-86	87
17	12	13-89	90
18	15	16-92	93
19	18	19-95	96
20	21	22-98	99
21	24	25-101	102
22	27	28-104	105
23	30	31-107	108
24	33	34-110	111
25	36	37-113	114
26	39	40-116	117
27	42	43-119	120
28	45	46-122	123
29	48	49-125	126
30	51	52-128	129
31	54	55-131	132
32	57	58-134	135
33	60	61-137	138
34	63	64-140	141
35	66	67-143	144
36	69	70-146	147
37	72	73-149	150
38	75	76-152	153
39	78	79-155	156
40	81	82-158	159
41	83	84-161	162
42	86	87-164	165
43	89	90-167	168
44	92	93-170	171
45	95	96-173	174
46	98	99-176	177
47	101	102-179	180
48	104	105-182	183
49	107	108-185	186
50	110	111-188	189
51	113	114-191	192
52	116	117-194	195
53	119	120-197	198
54	122	123-200	201
55	125	126-203	204

Table 6. Action level = 3.5 corn rootworm beetles per plant

No. Plants Sampled	Noneconomic Population–Resample in 7 days	Continue Sampling	Economic Population
3	–	0-59	60
4	–	0-63	64
5	–	0-66	67
6	–	0-70	71
7	–	0-73	74
8	–	0-77	78
9	–	0-80	81
10	–	0-84	85
11	–	0-87	88
12	–	0-91	92
13	–	0-94	95
14	–	0-98	99
15	3	4-101	102
16	6	7-105	106
17	10	11-108	109
18	13	14-112	113
19	17	18-115	116
20	20	21-119	120
21	24	25-122	123
22	27	28-126	127
23	31	32-129	130
24	34	35-133	134
25	38	39-136	137
26	41	42-140	141
27	45	46-143	144
28	48	49-147	148
29	52	53-150	151
30	55	56-154	155
31	59	60-157	158
32	62	63-161	162
33	66	67-164	165
34	69	70-168	169
35	73	74-171	172
36	76	77-175	176
37	80	81-178	179
38	83	84-182	183
39	87	88-185	186
40	90	91-189	190
41	94	95-192	193
42	97	98-196	197
43	101	102-199	200
44	104	105-203	204
45	108	109-206	207
46	111	112-210	211
47	115	116-213	214
48	118	119-217	218
49	122	123-220	221
50	125	126-224	225
51	129	130-227	228
52	132	133-231	232
53	136	137-234	235
54	139	140-238	239
55	143	144-241	242

Table 7. Action level = 4.0 corn rootworm beetles per plant

No. Plants Sampled	Noneconomic Population–Resample in 7 days	Continue Sampling	Economic Population
3	–	0-73	74
4	–	0-77	78
5	–	0-81	82
6	–	0-85	86
7	–	0-89	90
8	–	0-93	94
9	–	0-97	98
10	–	0-101	102
11	–	0-105	106
12	–	0-109	110
13	–	0-113	114
14	–	0-117	118
15	–	0-121	122
16	2	3-125	126
17	6	7-129	130
18	10	11-133	134
19	14	15-137	138
20	18	19-141	142
21	22	23-145	146
22	26	27-149	150
23	30	31-153	154
24	34	35-157	158
25	38	39-161	162
26	42	43-165	166
27	46	47-169	170
28	50	51-173	174
29	54	55-177	178
30	58	59-181	182
31	62	63-185	186
32	66	67-189	190
33	70	71-193	194
34	74	75-197	198
35	78	79-201	202
36	82	83-204	205
37	86	87-208	209
38	90	91-212	213
39	94	95-216	217
40	98	99-220	221
41	102	103-224	225
42	106	107-228	229
43	110	111-232	233
44	114	115-236	237
45	118	119-240	241
46	122	123-244	245
47	126	127-248	249
48	130	131-252	253
49	134	135-256	257
50	138	139-260	261
51	142	143-264	265
52	146	147-268	269
53	150	151-272	273
54	154	155-276	277
55	158	159-280	281

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